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VOLCANISM, GLOBAL CATASTROPHE AND MASS MORTALITY

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The effects of very large volcanic eruptions are well documented in many studies, mostly based on observations made on three historic eruptions, Laki 1783; Tambora 1815 and Krakatau 1883. Such eruptions have effects that are catastrophic locally and measurable globally, but it is not clear that even the largest volcanic eruptions have had global catastrophic effects, nor caused mass extinctions. Two different types of volcanic eruption have been considered as likely to have the most serious widespread effects: large silicic explosive eruptions producing hundreds or thousands of cubic kilometres of pyroclastic materials, and effusive basaltic eruptions producing ~ 100 cubic kilometers of lava. In both cases, the global effects are climatic, and attributable to production of stratospheric aerosols.

Volcanism is much the most catastrophic endogenic process that can affect the Earth. During large silicic pyroclastic eruptions, a caldera up to 10km in diameter may form in the space of a few hours or days, with pyroclastic flows travelling radially outwards for distances well in excess of 100km. Rampino, Self and Stothers [1] have explicitly addressed the issue of whether large volcanic eruptions could cause "nuclear winters". They conclude that while the environmental effects of the largest eruptions would be severe, the residence time of volcanic aerosols in the stratosphere is too short to produce prolonged climatic cooling and consequent mass extinctions, unless a positive feedback is invoked; for example a few cool summers leading to increased accumulation of snow and ice at high latitudes, so that the increased albedo would further cool the Earth. This feedback mechanism was first suggested by Bray [2].

Other possibilities need to be explored. Recent research on global change has emphasized the extreme sensitivity of the links between oceanic circulation, atmospheric circulation and climate. In particular, it has been argued that the pattern of ocean current circulation (which strongly influences climate) is unstable; it may rapidly 'flip' from one pattern to a different one, with global climatic consequences. A possible example of the profound changes that may be caused by minor geological phenomena is the diversion of Mississippi drainages of north America about 11,000 yr BP: cold meltwater from the north American continental ice sheet was diverted eastward from Lake Agassiz along the St. Lawrence valley in to the north Atlantic, rather than flowing southwards into the Gulf of Mexico; about 10,000 yr ago the southward drainage pattern was reestablished [3, and references therein]. The rapid cooling of the north Atlantic caused an abrupt return to severe Ice Age conditions around the north Atlantic shores with consequent dramatic (but not global) floral and faunal changes - the Younger Dryas. On a larger scale, Woodruff and Savin [4] have related profound changes in Miocene benthic faunas between the Atlantic and Pacific oceans at about 15 my ago to the pinching off a southwards flowing thermohaline current in the Indian ocean. Closure of the Bitlis-Zagros section of the Tethys ocean seems a possible cause of cessation of this southward flow of warm salty water [5].

If volcanism has been a factor in global environmental change and a cause of mass extinctions, it seems most likely that it has done so by providing a 'trigger' to other processes, for example by driving oceanic circulation from one mode to another. A relatively modest volcanic episode could easily cause drainage modifications comparable to that of the St. Lawrence, with widespread and unpredictable environmental consequences. A major volcanic episode, comparable in magnitude with the Deccan traps, could have profound consequences if it took place in a location in which it directly perturbed oceanic circulation. At the present day, for example, it would be conceivable for such an episode to effectively close the Drake Passage between Antarctica and South America, interrupting the climatically critical circum-Antarctic cold ocean current.

The paleogeography of the world at the KT boundary is well known through a wealth of geophysical and geological data; the paleoceanography is hardly known at all. If a triggering event of any kind (extra-terrestrial or endogenic) were to take place, it is difficult to retrodict its full global implications.

References

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